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LINGUISTIC AND COGNITIVE NETWORKS

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June 1969

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## LINGUISTIC AND COGNITIVE NETWORKS

The type of network treated in this paper is a network of relationships, and it is my intent to show how linguistic data and cognitional data can be accounted for by means of such networks. We shall start out by looking at some linguistic data, with a particular concern for identifying the relationships which they exhibit. That is, the emphasis is on their interrelationships rather than directly upon the items of data themselves. As we proceed, we shall observe how the individual relationships are organized into larger configurations forming networks of relationships, and we shall find that the types of relations and configurations of relations to be observed in linguistic data are also present in cognitional data. It then becomes interesting to view such linguistic and cognitive networks as models of the knowledge, or of some of the knowledge, that a typical human being has stored in his brain.

We may begin with the simple case of the adjective good, which, as we all know, has the comparative better. That is, we say better rather than gooder. Now what is the relationship between good and better? In the first place, better is of course a comparative and it ends in -er, like other comparatives, taller, higher, bigger, etc. Thus the -er is evidently an expression for the comparative element of the grammar, and better thus consists of two parts bett- and -er. The remainder bett- which is left after identifying the -er of better is clearly in some very close relationship with good. We may say that these two units of expression have the same meaning or content, since the difference in meaning is entirely accounted for by the -er, representing the comparative

element, as may be established by the fact that the pairs tall--taller, big--bigger show the same difference in meaning and differ only in the presence or absence of -er. In other words, there must be some underlying or more abstract entity GOOD which has the alternative representations gud and bet. These alternative expression units may be called alternate realizations of the more abstract entity (Figure 1a).

Now the expression I am referring to here is spoken rather than written expression. English, like many other languages, has both forms of expression available, but the spoken expression system occupies a more basic position in the mind of the individual, since it is learned first and the writing system is learned on the basis of the knowledge of the spoken expression system already present in the child's mind. That is, knowledge of the writing system, as internalized in the brain, is built upon that of the phonological system. Thus in the diagram "gud" is a symbolization chosen to be consistent with the phonological expression /gud/.

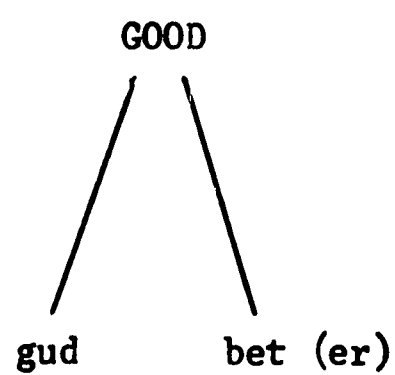
Now we may be more precise about the relationship between gud and bet: they are in an either-or relationship as expressions for the underlying entity GOOD. That is, GOOD is realized as either gud or bet, never as both of these at the same time. The relationship is diagrammed in Figure 1b, in which the quasi-rectangular symbol at the intersection of

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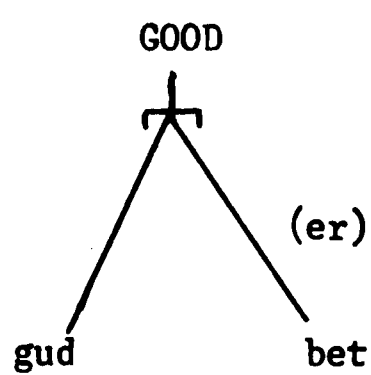
Insert Figure 1 about here

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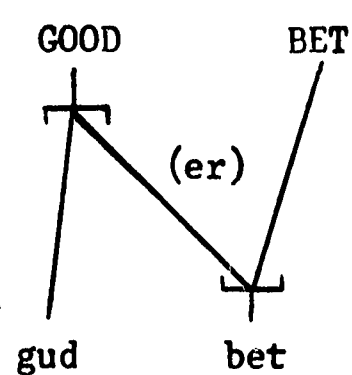
the lines may be called an "or" node. The "(er)" identifies the condition for the choice of bet as opposed to gud. This condition can also be incorporated into a diagram of relationships but I refrain from going into this matter in this brief introductory treatment and instead refer



(a)



(b)



(c)

Figure 1

the reader to the more technical account in Lamb 1966c. I also leave best out of this example just to keep it simple, since its inclusion would not affect the points under discussion.

Now this expression unit bet is also used as the expression for a particular verb, as in

I'll bet you that Teddy Kennedy will be elected President in 1972.

Here too we have an "or" relationship, but this one is of opposite direction, since we have a single expression unit as realization of either of two content units. Figure 1c shows that the abstract element GOOD is realized as either gud or bet, and this bet is a realization of either GOOD or BET.

Now it is already apparent from this very small amount of data that we must distinguish expression from content in the linguistic system as these often fail to correspond to each other in one-to-one relationships --- the single content unit GOOD is related to two separate expression units gud and bet, and the single expression unit bet is related to two separate content units. (For further discussion of expression and content, see Hjelmslev 1943, Lamb 1966a).

The linguistic system of the speaker's mind is sort of code, which relates meanings or concepts, at one end, to speech sounds, at the other end. In drawing diagrams of portions of this code, we follow the convention that the upward direction is toward meaning or concepts, while downward is toward speech.

Moving on, let us consider the English word den. We can analyze it, on the side of expression, as a sequence of three phonological units, d, e, n. This relationship may be represented by the diagram of Figure 2a,



in which the triangular node signifies and "and" relationship, since we have the phonological segments d and e and n rather than one or another of these segments. Moreover, the order d e n is significant, as represented by the left-to-right ordering of the connections of the lines to the bottom of the triangle, since if the order is reversed, for example, we get an entirely different linguistic unit, Ned.

Now it is relevant to identify these parts, d, e, n, of the expression since, among other things, they are found to recur in the expression of other linguistic units. For example n occurs not only as a component of den, but also in Ben, pen, men, and so forth, as represented in Figure 2b,

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Insert Figure 2 about here

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in which we may note that an upward "or" relationship is involved, since a given occurrence of n is a segment of either den or Ben or pen or men (not to mention other possibilities).

Now if we put these observations together we arrive at a configuration of relationships that may be diagrammed <sup>as</sup> in Figure 3 for a small sample of data.

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Insert Figure 3 about here

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In this diagram -d at the upper left is the suffix of rubbed, bugged, etc., and -n at the upper right is the suffix of taken, seen, etc. These units of grammatical level happen to be expressed by single phonological segments and therefore connect downwards to phonological units without any intervening "and" nodes.

This configuration of relationships may be called a sign pattern,

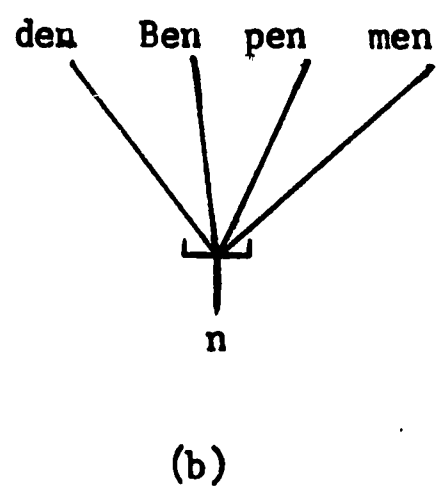
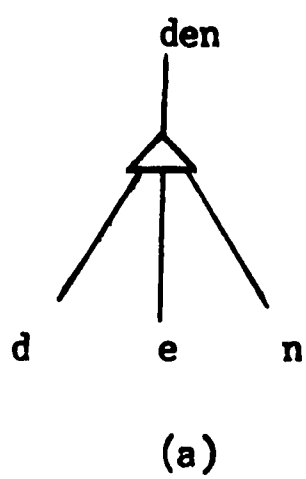


Figure 2

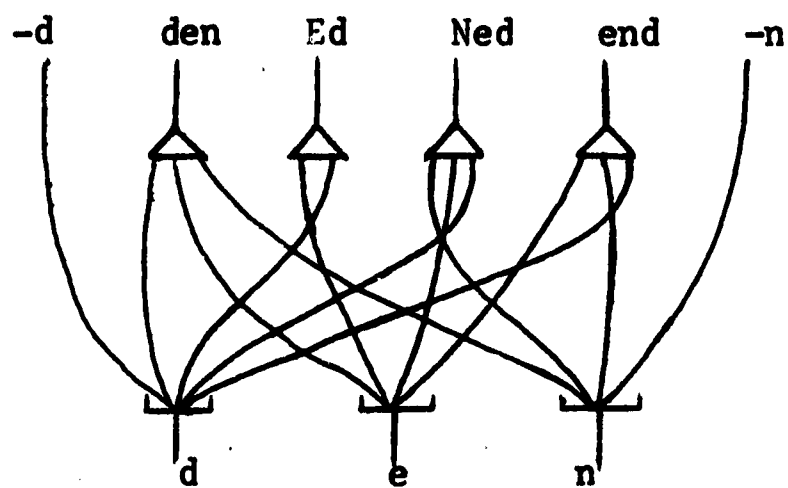


Figure 3



in keeping with the traditional concept of the linguistic sign (Saussure 1916, Hjelmslev 1943): each of these "and" nodes, with its connecting lines, represents a sign; the lower lines lead to the signifiants of Saussure, while the upper line leads to the signifié. A sign pattern is characterized by a row of "and" nodes with connections downward to a row of upward "or" nodes. There are more lines at the top of a sign pattern than at the bottom: if the partial sign pattern of Figure 3 were expanded to cover all of the material that a typical speaker of English has at this level in his internalized linguistic system, we would find a few thousand lines at the top and only about forty or fifty at the bottom. As -d and -n illustrate, some lines at the top of a sign pattern may connect downward to an upward "or" without any intervening "and" node. Such lines represent simple signs. The units at the top of this sign pattern may be called morphemes and those at the bottom may be called morphons. This use of the term morpheme is different from some uses of that term, in which it is applied to the combination of phonological units rather than to the single element which is realized by that combination of units. This difference in the way the terms are used is in keeping with the differences in orientation. The usual practise in linguistics, particularly in the Boas-Sapir-Bloomfield-Harris-Chomsky tradition, is to focus on the data, whereas our concern here is with the network of relationships which is manifested by the data. When one is focusing on data the morpheme is obviously a combination of smaller units; for example, a sequence of phonemes or a matrix of distinctive features. But when we look at the relationships which underlie the data we identify a single point in the network, which is connected to the phonological units, rather than being composed of them.

Now if we look a little more closely at the phonological segments of the sign pattern described above, we can see that they are not elementary — further analysis is possible. Notice that d, as in doe and n as in no, are pronounced with the same tongue position. For both of these segments, the apex of the tongue is against the bony ridge behind the upper teeth. This is also true of t as in toe; but the d differs from the t in being voiced. Similarly, m as in Moe, b as in beau, and p as in Poe are all pronounced with the lips. Moreover, the difference between m and n is the same as that between b and d, and the same as that between p and t. We could represent these relationships by means of a table (Figure 4).

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Insert Figure 4 about here

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But these same facts can also be completely represented in terms of the basic "and" and "or" relationships already identified (Figure 5). Here, however, the "and" connections are unordered, since the phonological components -- e.g. Closure and Labial in the case of b -- are simultaneous. So we recognize the unordered "and" in addition to the ordered "and".

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Insert Figure 5 about here

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Here we have another sign pattern --- a row of "and" nodes above a row of upward "or" nodes. We may distinguish between the sign pattern described above and this one by calling the former the morphemic sign pattern and this one the phonemic sign pattern. The units at the top of

	Lb	Ap	
Cl	p	t	Vd
	b	d	
Ns	m	n	

Figure 4

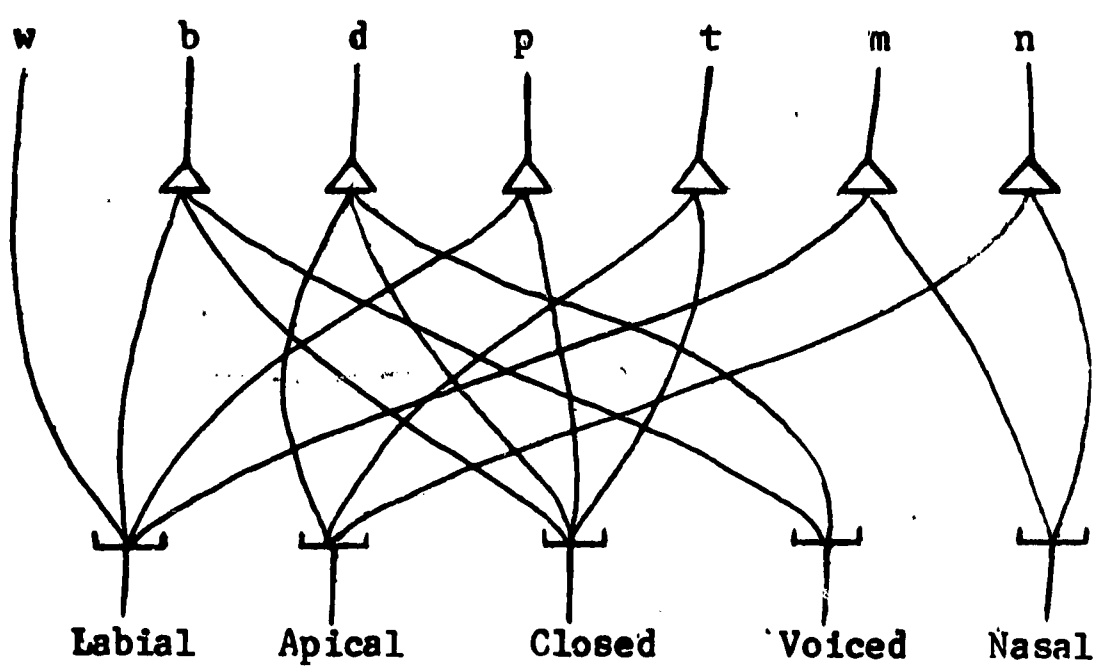


Figure 5

the phonemic sign pattern may be called phonemes and those at the bottom may be called phonons.

In Figure 5, only those phonons are shown which are distinctive - i.e., capable of distinguishing meaning. Thus m and n both have closure of the mouth, just as do b and d, but the closure is predictable with the Nasal component and is therefore non-distinctive. The phoneme w may be analyzed as having only one distinctive feature, Labial, so it provides an illustration of a simple phonemic sign, or simple phoneme. (Non-distinctive phonological components are supplied at a lower point in the network; cf. Lamb 1966b.)

In the linguistic code the phonemic sign pattern is clearly below the morphemic sign pattern, but if we consider further evidence we can see that it is not directly below the latter and that the morphon and the phoneme cannot be equated. For example, we find downward "or" relationships at this level similar as relationships to that exhibited by GOOD, gud, and bet. Consider the vowel sounds of the first syllables of

nation : national

sane : sanity

vain : vanity

Here we have two different vocalic units but obviously a single higher-level entity, since nation and the nation- of national clearly represent the same morpheme. This alternation is at a lower level of the system than that of gud and bet, since these two are altogether different phonologically.

We also find evidence of downward "or" nodes --- i.e., of alternation --- below the phonemic sign pattern. Consider the n of the prefix in- as in inorganic. Instead of in- we find im- in impolite, impatient. Just as nation and nation- of national are phonologically the same except for

the alternating vocalism, so m and n are the same except for position of articulation. The alternation is between Apical and Labial, but the Nasal component does not vary.

Thus we seem to have evidence for the recurrence of similar patterns of relationships at different levels of the linguistic system. And we can see further such stratification at a higher level than those considered so far.

It used to be supposed, in linguistics, that morphemes (i.e. units like good, den) have a direct relationship to meaning. But what about understand, undertake, undergo, go in for? If understand consists of the two morphemes under and stand, then how do we account for its meaning? But if we take understand as a single morpheme, as neo-Bloomfieldians are forced to do in keeping with their principle that the morpheme is a minimum meaningful unit, then how do we account for the fact that the past tense of understand is understood? If understand is one morpheme and stand is another, then the fact that their respective past tenses are understood and stood has to be treated as two separate facts, and one can only say, on the side, "What a remarkable coincidence!" It becomes even more remarkable when we encounter withstand and its past tense withstood. We have a similar situation with go — went, undergo — underwent, go in for — went in for, and we simply cannot adequately account for the facts except by abandoning the Bloomfieldian concept of the morpheme as a minimal meaningful unit --- i.e., a unit which is not composed of smaller units such that the meaning of the whole is the combination of the meaning of the parts. For understand and undergo are minimal meaningful units, and yet they may be analyzed into smaller grammatical

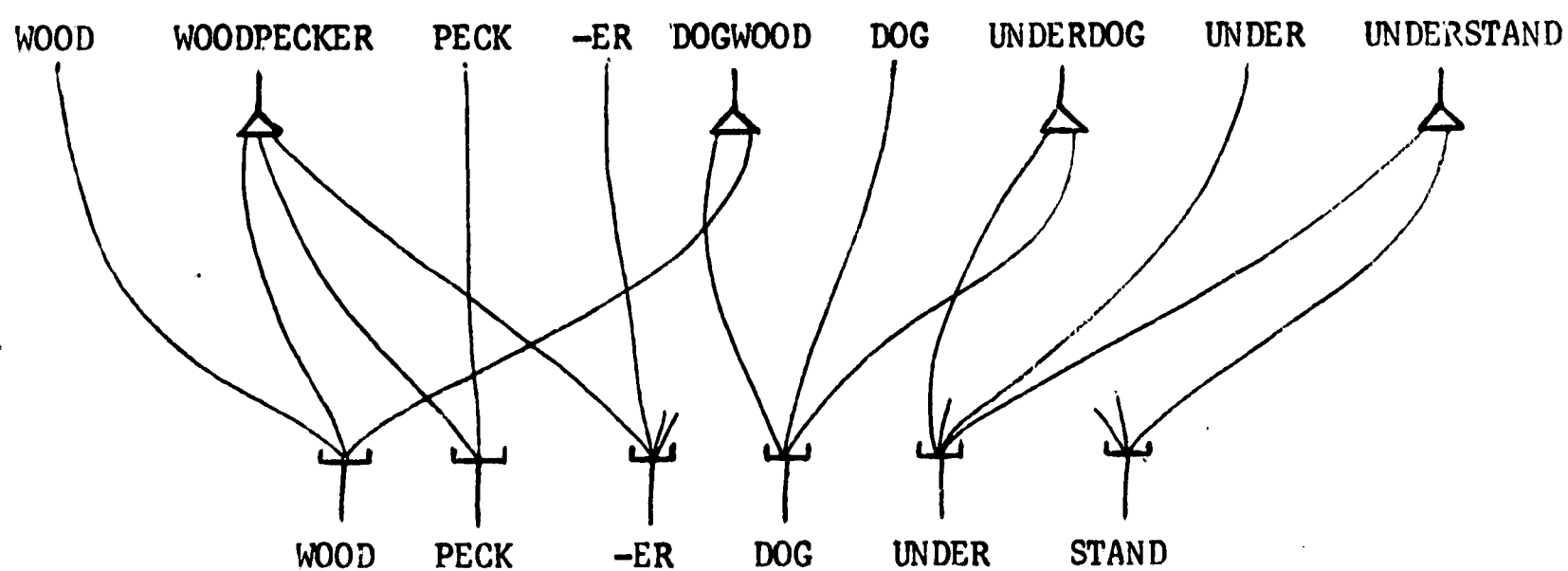


Figure 6



parts: under, stand, and go.

Thus we are dealing with another sign pattern, at a higher level than the morphemic sign pattern (Figure 6). This may be called the

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Insert Figure 6 about here

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lexemic sign pattern and the elements at its top and bottom may be called lexemes and lexons, respectively. (The term lexeme has a tradition going back to Whorf 1938, but its importance has been recognized by only a minority of linguists, even up to the present time.) With recognition of the lexemic sign pattern, the alternation involving go--went, undergo--underwent, etc. can be treated as a single alternation involving the lexon <sup>LN</sup>/go/. This alternation is at the same level as that of the morphemes <sup>M</sup>/gud/ and <sup>M</sup>/bet/, and the higher-level entity GOOD of which they are alternate realizations may now be identified as the lexon <sup>LN</sup>/good/.

Notice that, as with our other sign patterns, there are some simple lexemes in addition to the complex lexemes, and that we recognize complex lexemes for cases in which none of the participating lexons has alternating morphemic realizations, for example dogwood. If this were not done we would have to recognize a separate morpheme for dogwood, and the morphemic sign pattern would be unnecessarily complex (Figure 7).

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Insert Figure 7 about here

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By recognizing <sup>L</sup>/dogwood/ as a complex lexeme we take advantage of the morphemic signs <sup>M</sup>/dog/ and <sup>M</sup>/wood/, which are needed in any case (Figure 8).

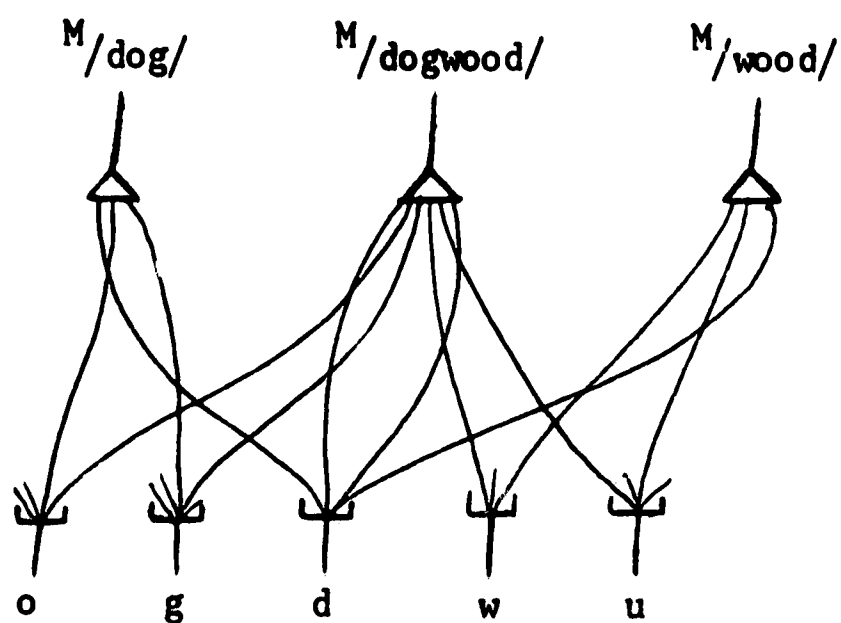


Figure 7

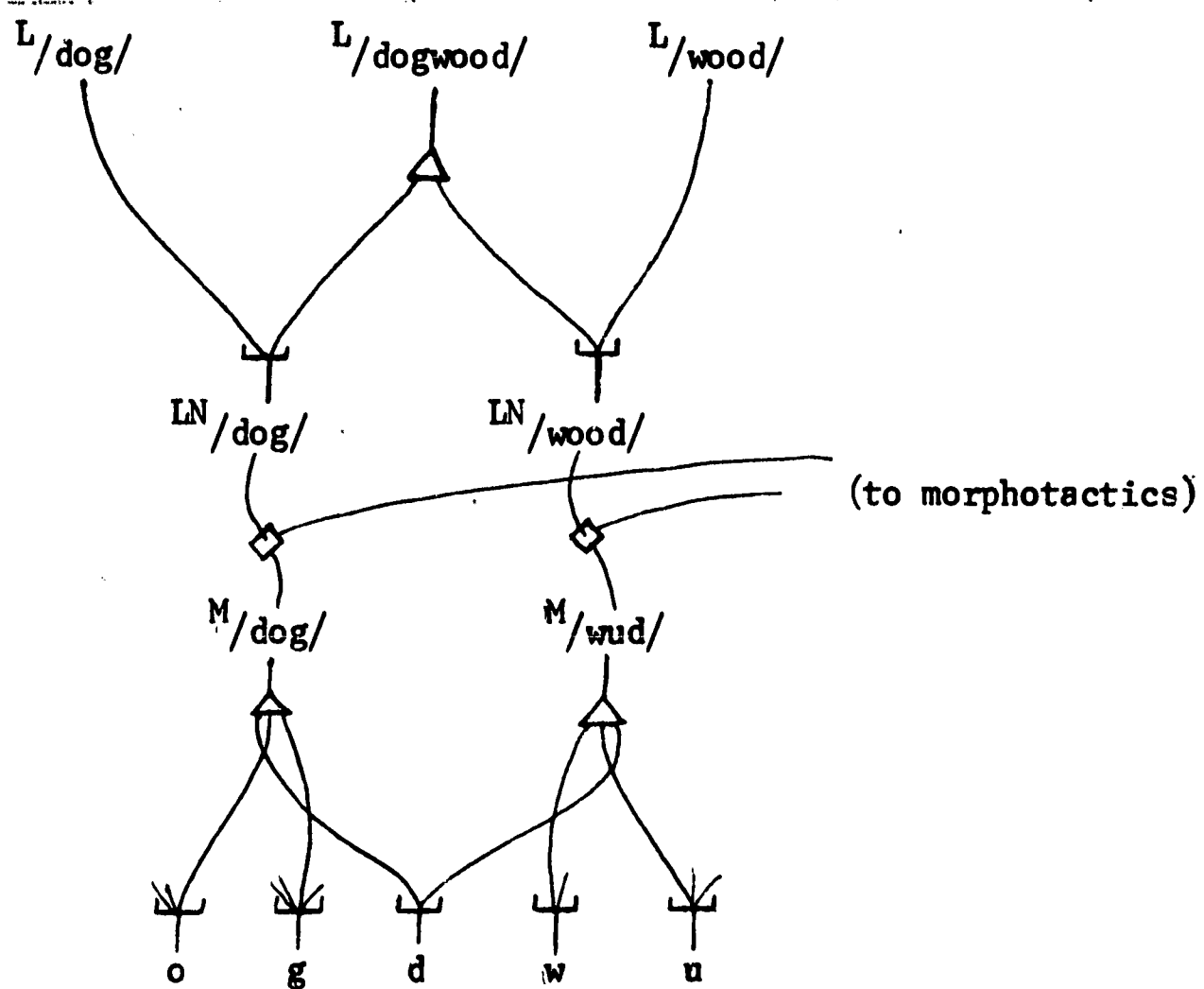


Figure 8

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Insert Figure 8 about here

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Another way of looking at this argument is to consider what it is necessary to add to the system when it acquires the new vocabulary item dogwood, on the assumption that dog and wood are already represented in the system. The alternatives may be seen in these diagrams, and that of Figure 8 requires the addition of fewer new lines.

In Figure 8, the diamond-shaped nodes in the middle are for connections to the morphemic syntax or morphotactics, the pattern of relationships which accounts for (i.e. generates) the allowable combinations of morphemes (see below). These diamond nodes should be added at the top of Figure 7 to make it comparable to Figure 8 and there would have to be three of them, since  $M/\text{dogwood}/$  would also require one.

Notice that woodpecker also requires a complex lexeme, even though its meaning is related to the combination of meaning of its parts --- but a baby woodpecker is still a woodpecker even though it doesn't peck wood, and a sparrow may occasionally peck at some wood, but that doesn't make it a woodpecker. (For further discussion of this point see Lamb 1966a).

Now we are ready to consider the status of the morpheme. What is it? Up to now I have referred to morphemes as elements and have identified them by means of symbols, e.g.  $M/\text{wud}/$  (wood). But what do these symbols stand for? Well, what are the properties of the morpheme  $M/\text{wud}/$ ? It has a phonological expression, a connection upwards to the lexemes  $L/\text{wood}/$ ,  $L/\text{woodpecker}/$ ,  $L/\text{dogwood}/$ , etc., (which in turn are connected to meanings) and a connection to a certain point in the morphotactic pattern

(representing the fact that it functions as a noun, perhaps a certain subtype of noun). And that's all --- it is nothing other than the point which has those connections. That is, it is nothing more than a position in a network of relationships. Thus the symbol <sup>M</sup>/wud/ is merely a label for that position --- it is not some kind of chunk of stuff, some kind of object which the network has in additions to its lines and nodes. Thus we could draw it just as accurately --- or rather, more accurately --- redraw the diagram as in Figure 9, with the symbols for the lexons and morphemes omitted since they do not constitute part of the structure of the linguistic system.

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Insert Figure 9 about here

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In this diagram the symbols for the lexemes (at the top) and for the morphons (at the bottom) are written at the sides of the lines which they label, rather than at the ends. They are merely labels, not part of the structure, by the same type of argument that applies in the case of morphemes. And similarly, the entire linguistic system consists just of relationships -- not symbols and relationships, just relationships, which may be diagrammed in a network of lines and nodes. Symbols are needed only at the end points of a diagram. In a network diagram of the whole of a linguistic structure (which would take far too big a sheet of paper to be a feasible undertaking), symbols would be needed only for phonetic features, at the bottom, and concepts, at the top. On the other hand, diagrams are in general much easier to read if we sprinkle labels around rather liberally; but from now on the labels will be at the sides of lines.

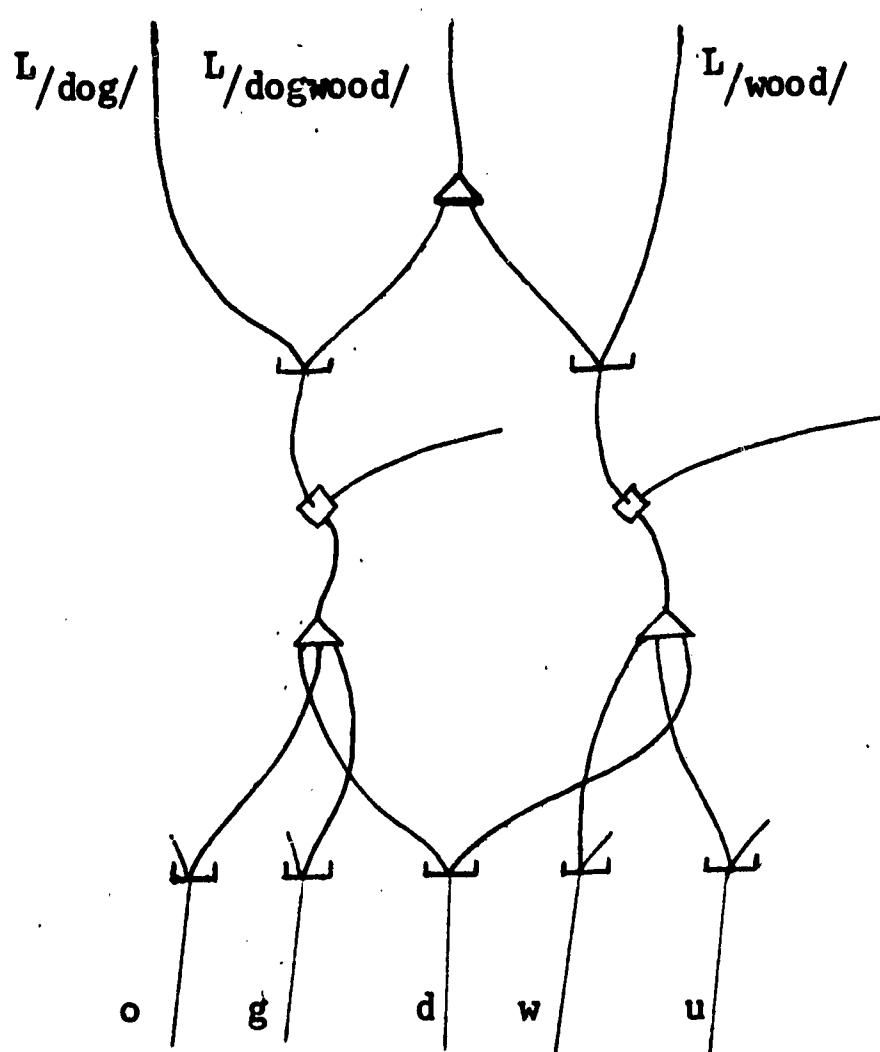


Figure 9

This point has been so widely misunderstood by critics of stratificational theory that one must conclude that it is rather difficult to understand; or at least it is difficult for those who are accustomed to the type of thinking that has prevailed in the Boas-Sapir-Bloomfield-Harris-Chomsky tradition. In this tradition there have been two tendencies in description, called "item-and-arrangement" and "item-and-process" (Hockett 1954). In the former, to give a grossly oversimplified account, one has linguistic items together with rules or other statements specifying how these items are arranged, while in the item-and-process approach one has items together with rules or other statements specifying operations performed upon these items. Now there has often been controversy between these two approaches, but they are really just two versions of the same basic tradition. Just as the New Left of politics opposes itself to both the Old Left and the Old Right, which it considers to be two varieties of the same basic mistake, so the relational approach in linguistics, which stems from Hjelmslev (1943; cf. Lamb 1966a), must be distinguished from both varieties of the item-and-(process/arrangement) approach, since linguistic structure, in its view, does not have items at all, nor does it have rules.

Now if we look further we find still another sign pattern, for there are "crystallized" combinations of lexemes which must be considered as units for their meanings to be understood: he'll never get to first base, he's got two strikes against him, don't take any wooden nickels, he put his foot in his mouth, as far as .... is/are concerned. This one may be called the sememic sign pattern, and the lines at the top and bottom of it may be called sememes and semons, respectively. (The term sememe was first used by Noreen 1903-1918). We also find alternation



(i.e. downward "or" relationships) among lexemes as realizations of semons, just as at lower strata. The semon <sup>SN</sup>/future-tense/ is realized as <sup>L</sup>/will/ in John will be late but as <sup>L</sup>/be-going-to/ (a complex lexeme) in John was going to be late in which <sup>S</sup>/future/ functions within the context of <sup>S</sup>/past/. Similarly, <sup>SN</sup>/can/ is realized as <sup>L</sup>/can/ in John can understand Hjelmslev but in the future it is realized as <sup>L</sup>/be-able-to/ (a complex lexeme), as in John will be able to understand Hjelmslev. Another example (borrowed from Bennett 1968) is furnished by <sup>SN</sup>/although/, which is realized in three different ways in:

They left although it was raining.

They left in spite of the rain.

It was raining. Nevertheless they left.

Now there are a number of other relationships to be found among lexemes and between lexemes and sememes. Some of them have been recognized for years by the man on the street (who, by the way, is not necessarily on the street); but it has not generally been realized how simple they are when analyzed into elementary relationships. Some of the more commonly noted phenomena are these:

First, a lexeme can have more than one meaning. An example is the English word table, which can designate either a piece of furniture or a type of display of information on the page of a book.

Second, different lexemes can have the same meaning, for example big and large.

Third, the meanings of some lexemes can be analyzed into components of meaning. For example, the English word mare can be analyzed into the

components female and horse; similarly, doe has the components female and deer, and hen has the components female and chicken.

A fourth observation is that some pairs of lexemes have opposite meanings. An example is the pair big and little.

Fifth, there are combinations of lexemes which have meanings different from the combinations of their separate meanings. These are often called idioms. We have already taken care of them by means of the sememic sign pattern. (And some of the things commonly called idioms are accounted for by the lexemic sign pattern.)

Let us take a look at the other four of these commonly observed phenomena.

The first was that a lexeme may be connected to more than one sememe, for example the table in the book as opposed to the book on the table. This is simply an upward "or" (Figure 10).

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Insert Figure 10 about here

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The second observation was that different lexemes may be connected to a single sememic unit, for example big and large. This is merely a downward "or" relationship, and further examples are already given above. Note that big and large are not completely synonymous (and indeed complete synonymy is doubtless impossible), since large is not substitutable for big in he's a big fool, he's a big man on campus, etc. This fact in no way destroys our recognition of big and large as synonyms. It only means that  $L_{big}$  is a realization of other semons besides the one that may alternatively be realized as  $L_{large}$  (Figure 11).

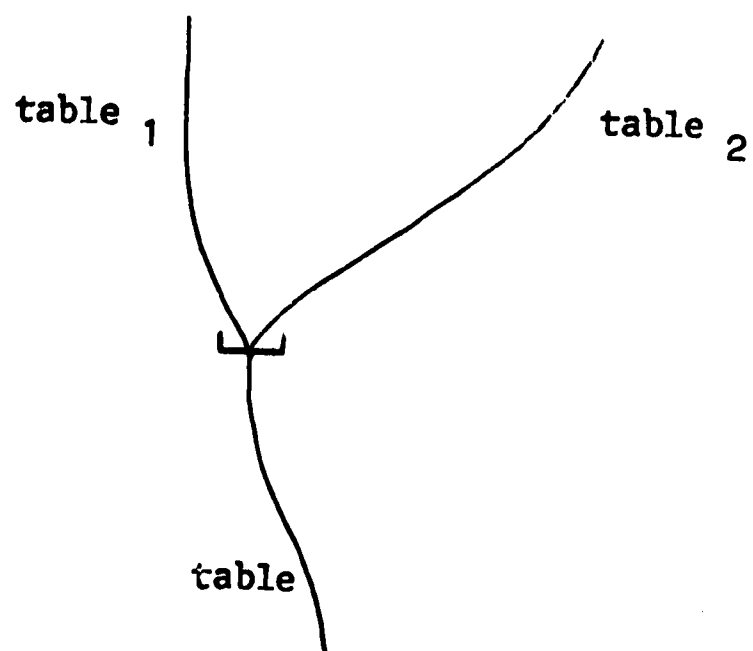


Figure 10

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Insert Figure 11 about here

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The third of our semantic observations was that some lexemes connect to combinations of sememes. The lexeme mare is connected to two sememes, which we may label horse and female. Now this is simply an upward "and" relationship (Figure 12).

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Insert Figure 12 about here

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Thus, as with the "or" relationship, we must recognize two directions, upward and downward.

The next observation was that some pairs of lexemes have opposite meanings. As examples we have big and little, high and low. The name antonymy has often been used for this type of relationship, and the items of opposite meaning are called antonyms. But actually there is more than one way in which linguistic units can be opposite in meaning. In the case of such pairs as big and little, large and small, tall and short, the second member of each pair is a negative of the first; little means not big, small means not large, short means not tall, and so forth. But the same is not true for come and go. To not come is not the same as to go. Rather, the difference between these two is one of direction: to come is to move toward the speaker or his point of reference, to go is to move otherwise. One says come here and come to my party, but I will go there and I will go to Mary's party. Another pair showing this same relationship is bring and take. One says bring it here but take it away. But go and take are used not only for movement away from the speaker; they are also

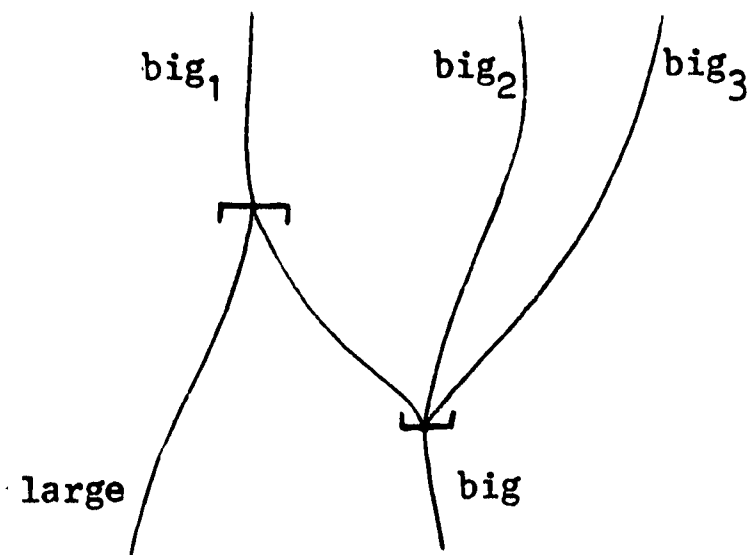


Figure 11

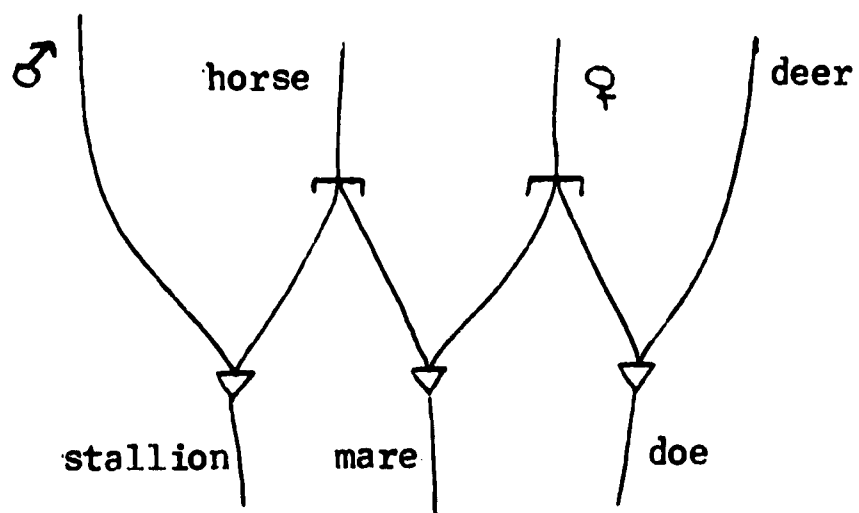


Figure 12

more general terms, which cover movement without a specific directional orientation. We may say that go is the unmarked member of the pair, while come is marked for direction towards the speaker or his point of reference. In the same way, bring is marked while take is unmarked. In providing the structural analysis for these pairs, we say that the marked member of each pair has an additional sememic component ; let us call it <sup>S</sup>/hither/. Thus the sememic sign bring leads upward to two sememes, <sup>S</sup>/take/ and <sup>S</sup>/hither/ (Figure 13).

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Insert Figure 13 about here

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Let us now return to the pairs high and low, big and little, large and small. Here one also observes that in each pair one member is marked while the other is unmarked. Little means specifically not big; and big, while it covers the opposite of little, is also a more general term. If the speaker of English asks about the size of an object and does not know whether it is big or little he says, "how big is it?" not, "how little is it?" He does not say "how little is it?" unless he already know that it is little. In other words, little is the marked term, while big is unmarked. By applying the same test we may determine that small is marked while large is unmarked, low is marked while high is unmarked, near is marked while far is unmarked; and so forth. As before, the marked terms are those which have the additional component; and in this case that additional component means 'un-'. In other words, little is to be analyzed as "unbig", near as "unfar", and so forth (cf. happy--unhappy, funny--unfunny.) These relations are diagrammed in Figure 14.



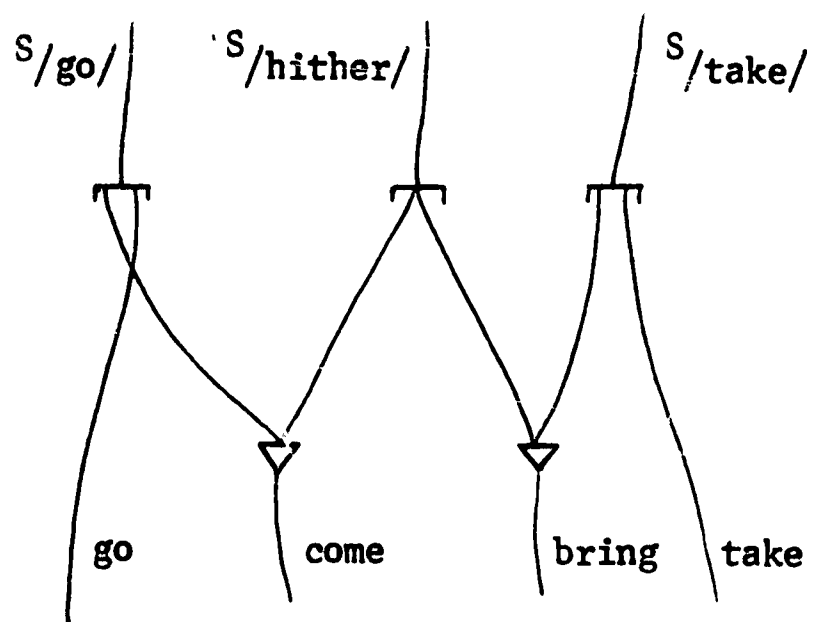


Figure 13

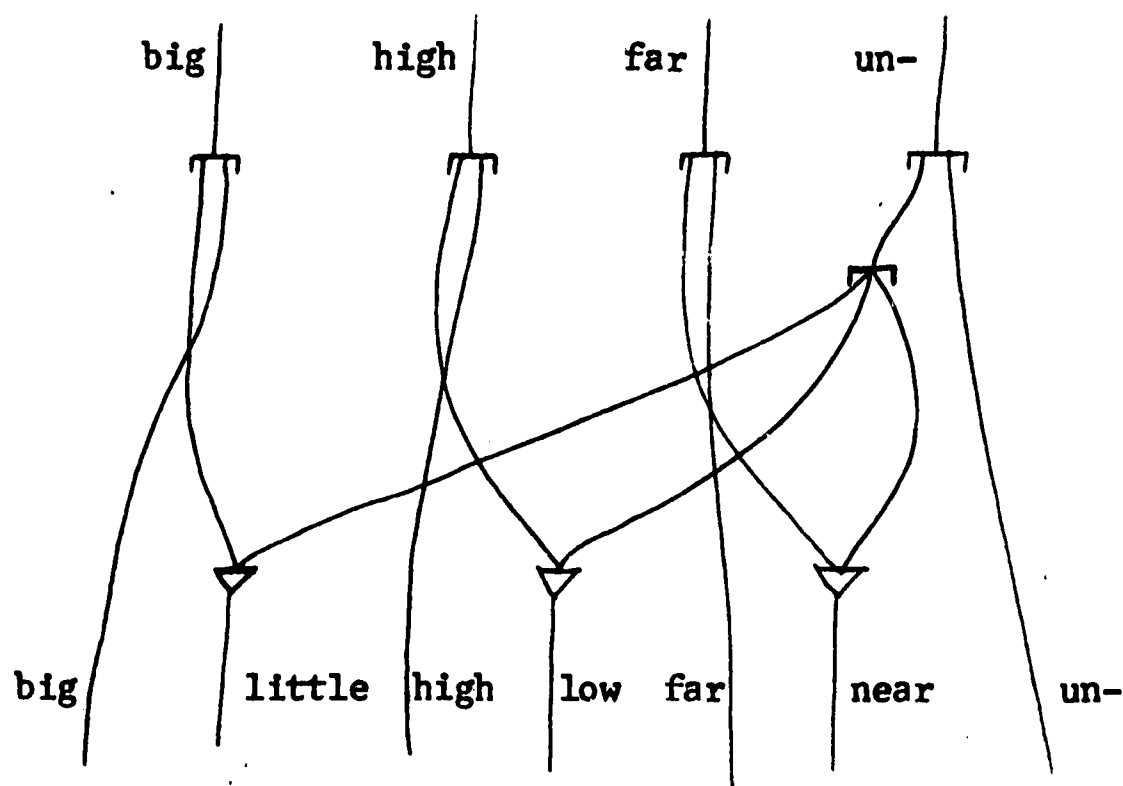


Figure 14

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Insert Figure 14 about here

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Here, as in the preceding diagram, I have used a new variety of "or" node, in which the lower lines connect at different points. This node may be called an ordered "or", but in this case the ordering is a matter of precedence rather than temporal ordering: the left connection is chosen where possible -- that is, we don't have a free choice between little and \*unbig; the former takes precedence.

Let us now turn to male and female, a pair which exemplifies still another relationship. In this case, unlike the others, we do not find that one member of the pair is complex relative to the other. It is not correct that female is merely the negative of male. Inanimate objects are not male, but they are not therefore female. The actual relationship of these terms lies just in the fact that they are members of a class which has only two members. This class is in the cognitive system, and it is also present in the semotactics, i.e. the syntax of sememes.

To further illustrate how semantic relationships may be diagrammed in the stratificational network notation, let us consider the following observations: old man is ambiguous, since in addition to its literal meaning (for which old and man represent separate lexemes) it is a designation for "father", which may also be realized as <sup>L</sup>/father/ or <sup>L</sup>/dad/. But <sup>L</sup>/father/ is also an alternative to <sup>L</sup>/priest/ as a designation for the sememe <sup>S</sup>/priest/. Now <sup>L</sup>/man/ is ambiguously a designation for a human being or a male human being. That is, it realizes <sup>S</sup>/human-being/ and optionally also the sememe <sup>S</sup>/male/. In the diagram below, the optionality is indicated by the upward "or" with one line connecting to

a small circle which means zero or nothing-- that is, the upward connection at this point is either to <sup>S</sup>/male/ or to nothing. And <sup>S</sup>/human-being/ may alternatively be realized as the lexeme <sup>L</sup>/human-being/, a complex lexeme connecting to the lexons <sup>LN</sup>/human/, <sup>LN</sup>/be/, and <sup>LN</sup>/-ing/. All of these observations are incorporated in Figure 15. This diagram also shows the points of connection to the lexotactics, i.e. the syntax of lexemes. These are the diamond-shaped nodes in the middle.

---

Insert Figure 15 about here

---

I have now mentioned in passing the existence of three syntactic patterns, at the sememic, lexemic, and morphemic strata. It will come as no surprise that one also finds evidence for a syntax of phonemes, i.e. a phonotactics. To give some idea of what a tactic pattern looks like, I provide in Figure 16 a partial morphotactics for a simple quasi-language that bears some resemblance to English but is much simpler.

---

Insert Figure 16 about here

---

Notice that this pattern is made up of the same relationships that we have previously identified. This diagram indicates that a clause consists of a noun phrase followed by a tense followed by a predicate. There are three types of predicates: be followed by an adjective or a noun phrase, a transitive verb followed by a noun phrase, or an intransitive verb. The upward "or" above the noun phrase construction indicates that the noun phrase can serve in any of three tactic functions, and similarly an adjective can serve in either of two tactic functions. Finally, a

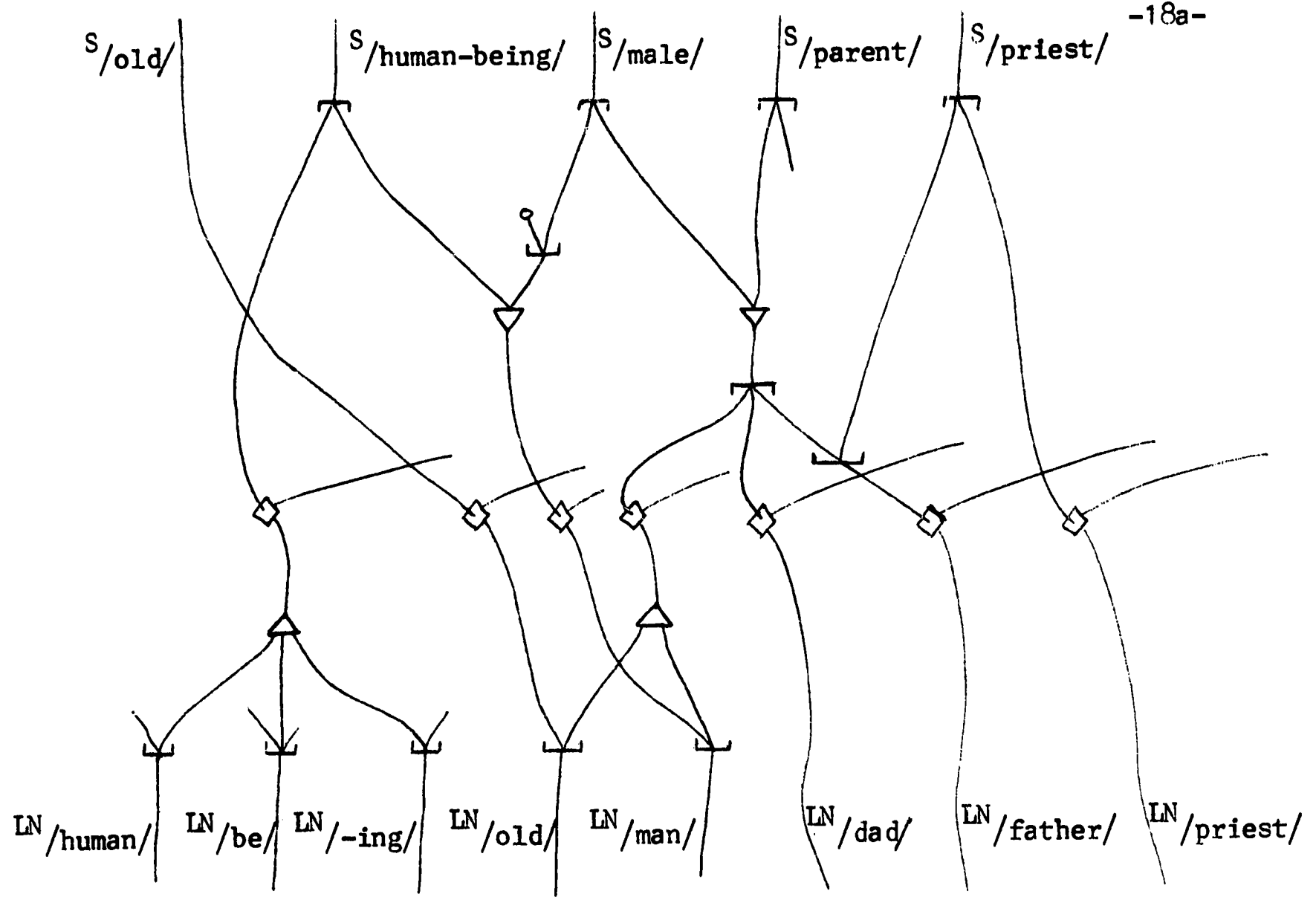


Figure 15

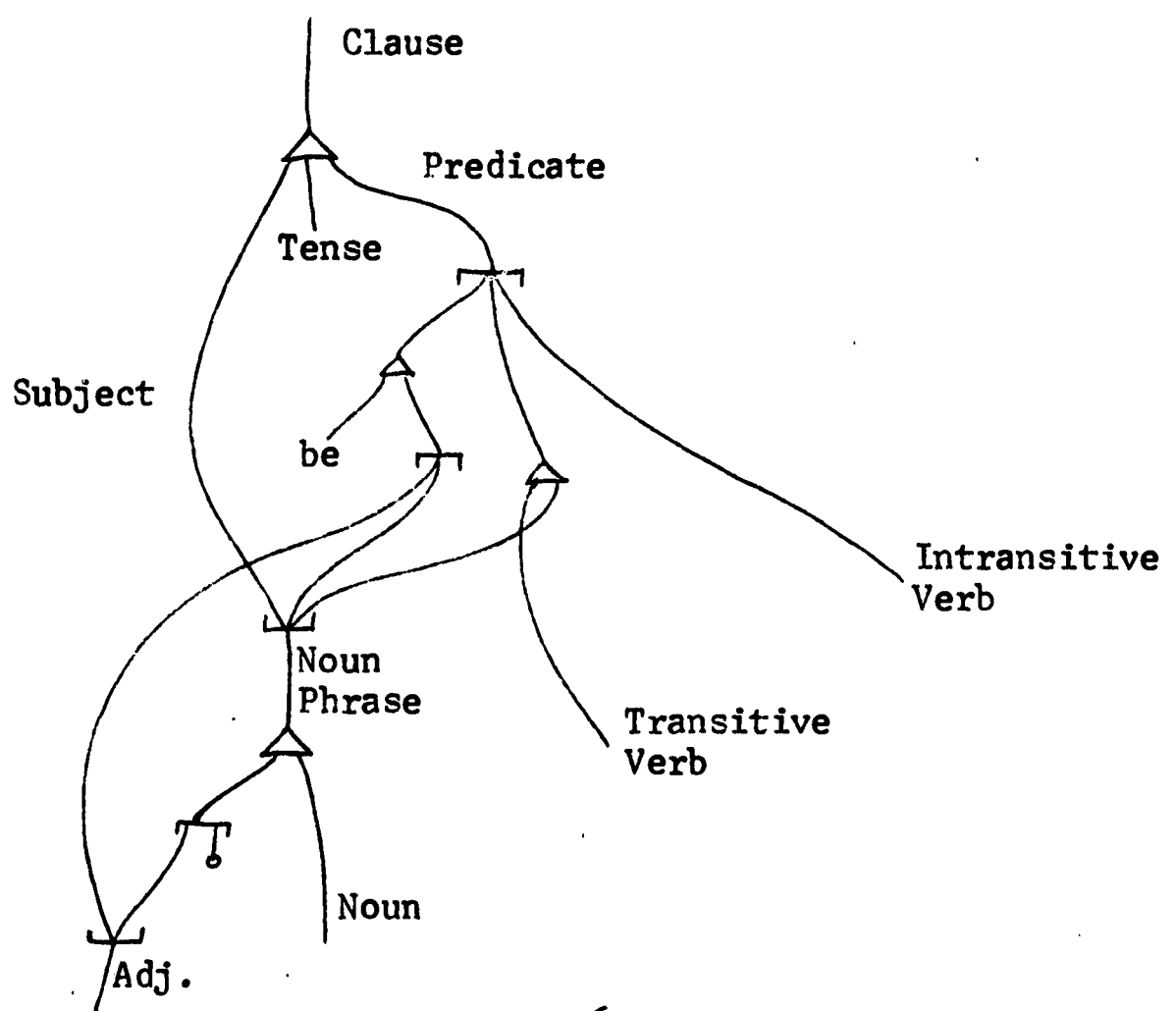


Figure 16

noun phrase consists of a noun optionally preceded by an adjective (that is, the downward "or" provides a choice between nothing and an adjective).

Now I have already mentioned that the points at which a tactic pattern connects to the rest of the network (which may be called the realizational portion) are diagrammed as diamond-shaped nodes. They may be called diamonds. The diamond is something like an "and" node, but it is more complicated than those considered so far. The usual type of diamond has three connections, as shown in Figure 17a.

Figure 17b shows a less common type of diamond, which provides a connection of a line from the higher stratum to the middle of a tactic line rather than the end. This type of diamond is used for higher-stratum elements which are realized by features of arrangement. Figure 17c shows another type of diamond, which provides for determined elements, i.e. elements whose presence is determined by the tactics and which therefore have no connection to the higher stratum. This is not really a node at all, since it has only two connecting lines; but it is a convenient notational convention which makes possible a clear boundary between the tactic pattern and the realizational lines.

---

Insert Figure 17 about here

---

It is convenient to visualize a tactic pattern as occupying a horizontal plane which intersects the vertical lines of the realizational portion of the linguistic network. The points of intersection are the diamonds. Since we find several tactic patterns (see below), the linguistic network has a series of parallel horizontal planes, the tactic patterns, intersecting the vertical lines at several strata from top to bottom. In visualizing the overall network it should further be kept in mind that



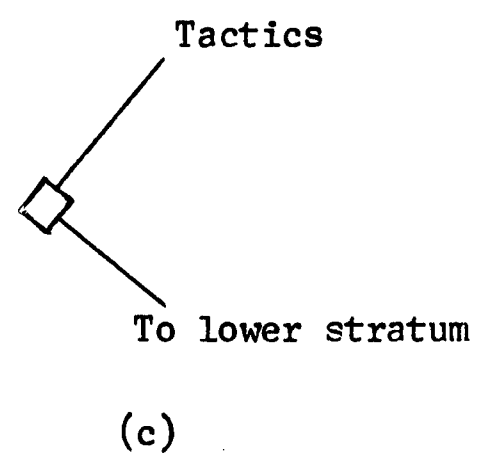
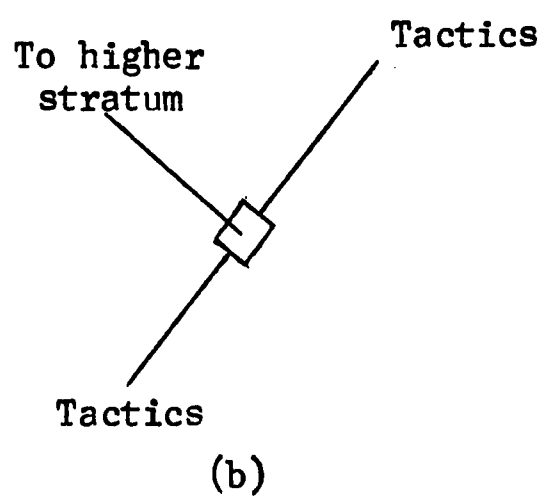
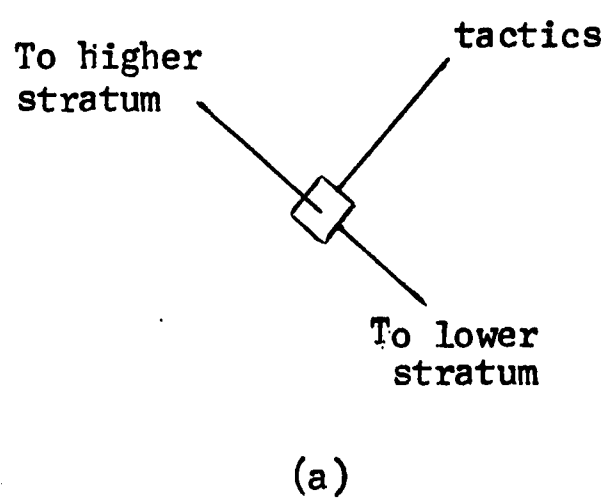


Figure 17

the lower strata have relatively fewer lines and nodes than the upper since a sign pattern has more lines at its top than at its bottom. That is, the network is much larger at the top than at the bottom.

To see how the diamonds function, let us first consider the question of how a tactic pattern chooses among alternative elements of the realizational portion. We may take the case of a morphotactics and the choice between alternative morphemes, say noun stems. (In this oversimplified morphotactics, derivation and inflection have been omitted.) If the simple morphotactic pattern diagrammed above is viewed as a generating device, then at the point 'Noun' we encounter a problem of choosing between the available nouns. Now what the network has at that point is (let us say for this simple quasi-language) shown in Figure 18.

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Insert Figure 18 about here

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When the 'Noun' line of the morphotactics is activated, we may say that each of the lines coming down from the "or" node is activated, since although it is an "or" node, there is no way of knowing at just that point which line to choose. The choice is determined by the next higher stratum, which activates one of the lines going into these diamonds from above. Here the diamond acts like an "and" node. If the semantic element for "house" has been activated, then we may say that the line marked by a star is activated, and when the two connections to diamond 'x' are activated, the third line, leading down to the morpheme <sup>M</sup>/house/, is activated.

Now in this same way the tactics determines the choice between alternative realizations in many of the cases where downward "or" nodes are present in the realizational portion. In the example of <sup>L</sup>/although/, <sup>L</sup>/in-spite-of/, and <sup>L</sup>/nevertheless/, mentioned above, the three realizations

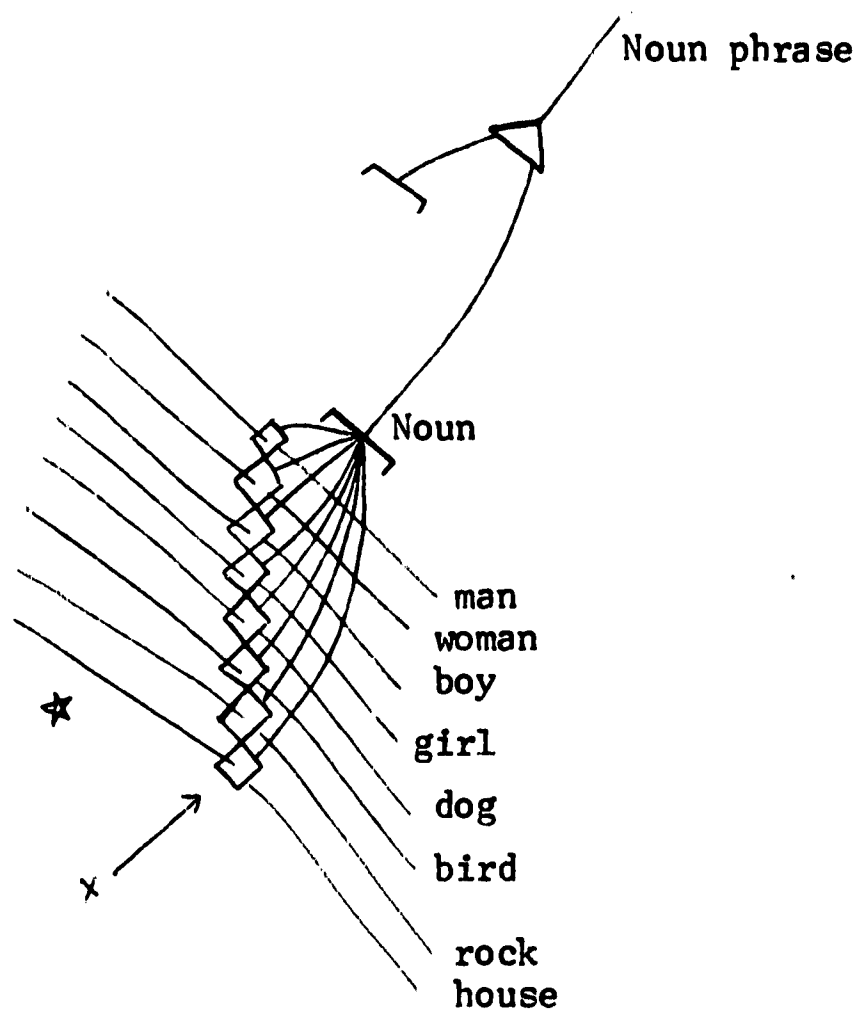


Figure 18

occur in three different lexotactic environments: <sup>L</sup>/in-spite-of/ is a preposition, occurring with noun phrases in prepositional phrases; <sup>L</sup>/nevertheless/ is a clause introducer; and <sup>L</sup>/although/ is a clause linker, occurring with two clauses (unlike <sup>L</sup>/nevertheless/, which occurs with single clauses). The situation is diagrammed in Figure 19.

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 Insert Figure 19 here  
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Here too we may say that at the downward "or", in this case in the realizational portion, all of the downward lines are activated when the upper one is, and the tactics will determine the choice since in any instance only one of the three lines, which connect to three different positions in the tactic network, will be active. Only that diamond which has both of its upper lines activated will activate the lower line, leading to one of the realizations. Here we see the tactic pattern operating as a sort of filter, filtering out unwanted possibilities during the encoding process. A tactics also serves, in encoding, to provide for the temporal ordering of line activations at its level, resulting in the sequencing of the expressions which are put out from the bottom of the network.

In decoding, i.e. in moving upwards through the network from expression to content, the diamond also functions as an "and" node, but one of different direction. Consider the morpheme <sup>M</sup>/wel/ well, which has four different meanings in:

John swims very well

Well, I guess so

They dug a deep well

Last week he was sick but today he is well

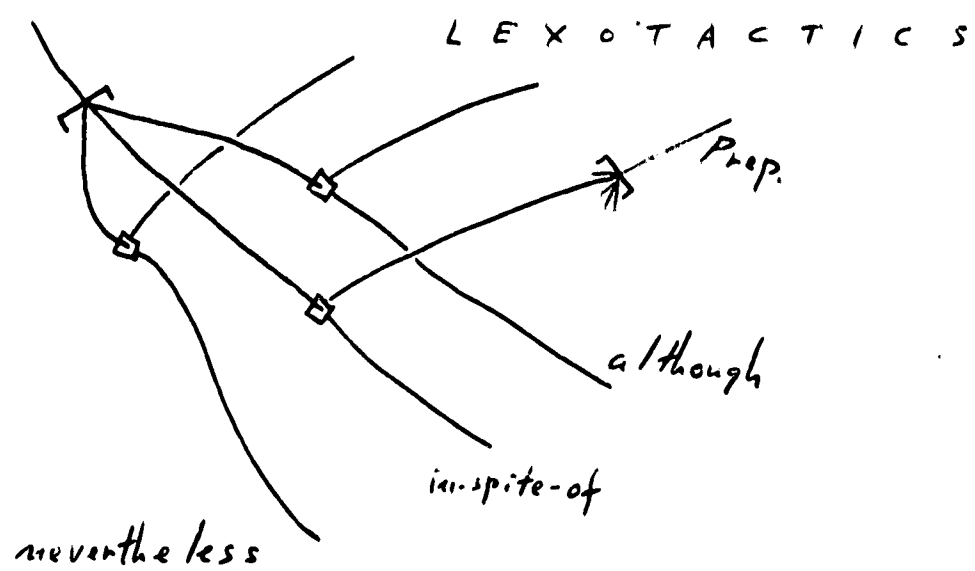


Figure 19

Although well is quadriguous (4-ways ambiguous) the context provides a resolution so that only one meaning comes through in each of the four examples above.

We may account for this fact by means of the function of the diamonds in the diagram of Figure 20. These four meanings are correlated with four different morphotactic functions, which we may label adverb, conjunction, noun, adjective. This means that the four diamonds are connected to four different positions in the morphotactics.

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Insert Figure 20 about here

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In decoding, the upward signal from the line <sup>M</sup>/wel/ is transmitted along all four lines to all four diamonds, since of course each is a possibility if no context is taken into consideration. But the tactics, in any of these four sentences, is in a position to accept only one of the possibilities. That is, only one of the four lines from the tactics is activated, and that one determines the choice. The diamond is thus functioning as a type of "and" node, but one of different direction from that involved in encoding. Thus the tactic pattern, through the use of the diamonds, acts as a filter also in the decoding process, in this case for filtering out the tactic misfits, so that ambiguities are automatically resolved.

Let us now consider an example of this phenomenon at the next higher stratum. The sentence John found a book on Broadway is ambiguous: John might have found a book whose subject matter is the street named Broadway, or it might be that it was on this street that he found the book. But now consider these two related sentences:



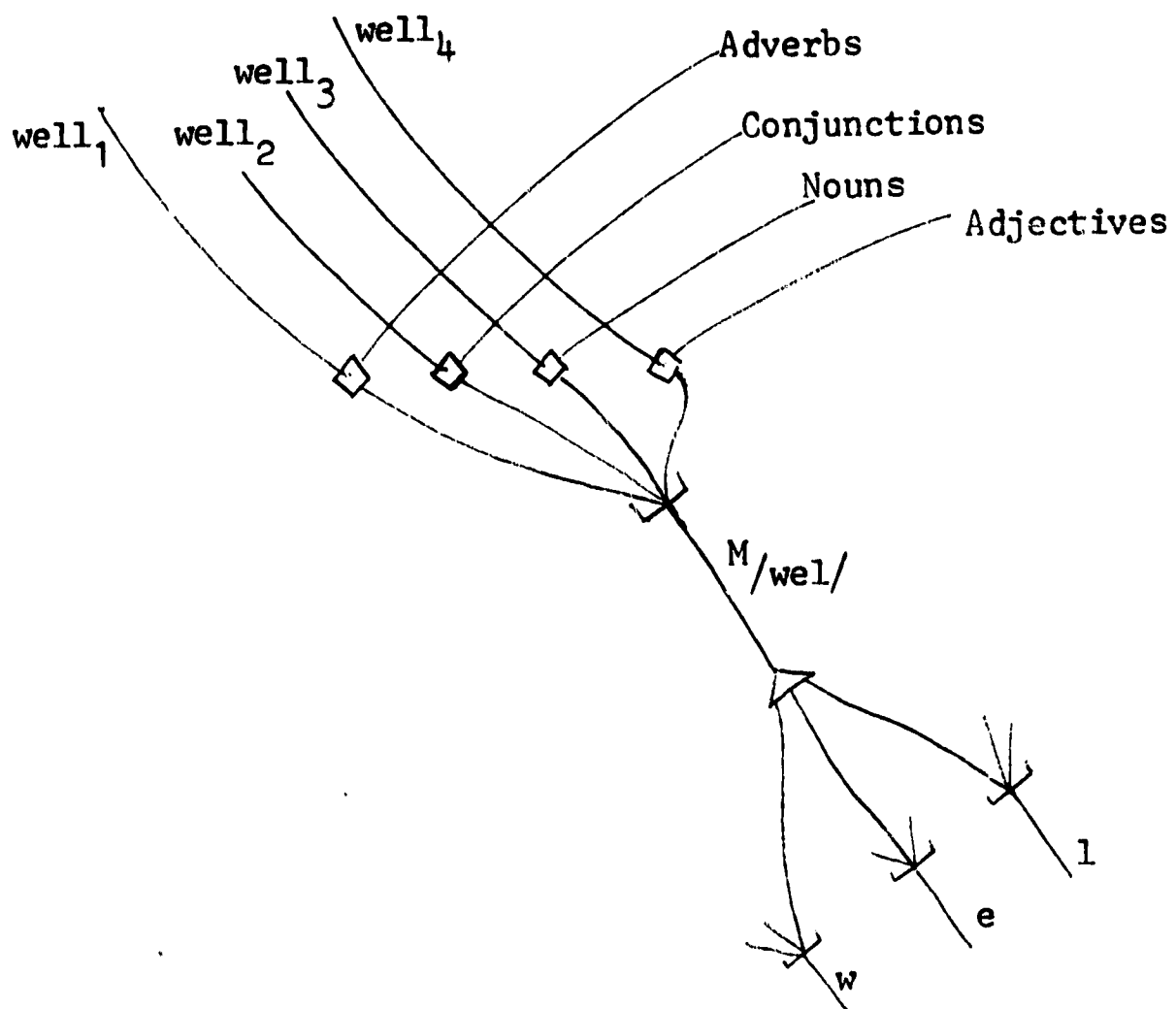


Figure 20

John found a bracelet on Broadway.

John found a book on yoga.

These two sentences are unambiguous. Yet their syntactic structure according to the morphotactics is identical to that of the ambiguous sentence. The three sentences are equally ambiguous according to the morphotactics alone, because in all three cases it allows the prepositional phrase to modify either the preceding noun or the verb phrase. But only the first of these three sentences is really ambiguous because for it the lexotactics also allows two interpretations. The ambiguity involves not primarily the two possible morphotactic interpretations but the lexeme on, which connects upward to two different semons, <sup>SN</sup>/on<sub>1</sub>/ for location on a concrete object, as in on the floor (or temporal location on a day, as in on Tuesday) and <sup>SN</sup>/on<sub>2</sub>/ as in a book on yoga. The lexotactics of English specifies that the locational /on<sub>1</sub>/ can occur only with members of the categories of concrete objects and certain time periods, while /on<sub>2</sub>/ can occur only with members of the category

Insert Figure 21 about here

of types of discourse. This category includes objects such as books and speeches and actions like talking, as in a book on yoga and he spoke on yoga. The sentence John found a book on Broadway is ambiguous because both of these interpretations for the lexeme <sup>L</sup>/on/ are accepted by the lexotactics: book is a type of discourse and Broadway is a concrete object. But the sentence John found a bracelet on Broadway is unambiguous because the lexotactics rejects one of the interpretations offered by the morphotactics, since bracelet is not a type of discourse. Similarly, John found a book on yoga is unambiguous since yoga does not belong to the category of concrete objects in the lexotactics. And notice further that in the sentence \*John found a bracelet on yoga both /on<sub>1</sub>/ and /on<sub>2</sub>/ are filtered out by

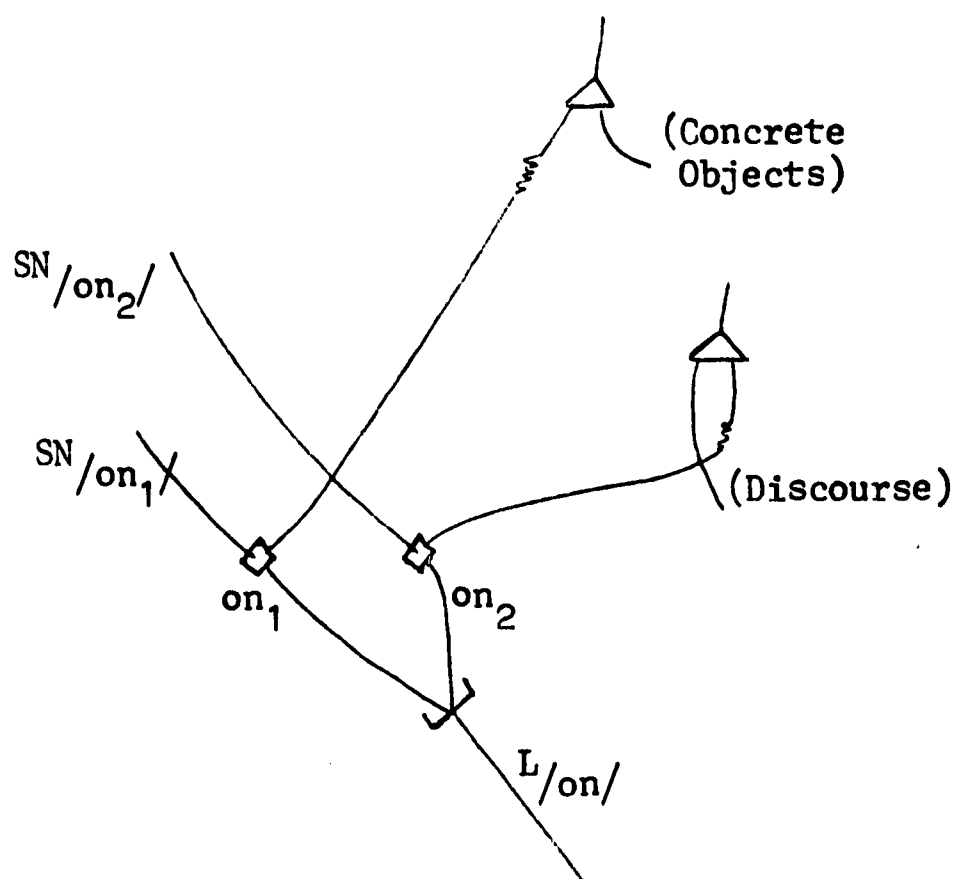


Figure 21

the lexotactics, since neither of them finds a suitable tactic environment. (For further discussion see Lamb 1966d.)

We have now seen some evidence for the existence of both a lexotactics and a morphotactics. That the morphotactics is independent of lexotactics is indicated also by the fact that it generates a larger set of combinations of morphemes when taken by itself than when it operates under control of the lexotactics. For example, \*underwhelm, \*underhold, \*retroduce are morphotactically well-formed but they don't have any lexemic decodings. This property of the morphotactics enables it to supply new combinations of morphemes for new lexemes when the occasion demands: acid-head, transistor, video-tape, over-kill, credibility-gap, moon-shot.

Likewise, the phonotactics generates a larger set of combinations than the set of phonemic realizations of morphotactic combinations. The phonotactics generates the set of all well-formed combinations of phonemes, including many which are known as nonsense syllables -- i.e., combinations of phonemes which are phonotactically well-formed but which are not decodable in the morphemic system. Thus a facility is also available for the formation of new morphemes.

Now I mentioned above that in a diagram of a complete linguistic network, symbols would be needed only at the top and the bottom, for concepts and phonetic features, respectively. We are now ready to consider the question: what are these concepts, or cognitive elements? If we look at cognitive data with a view to their relationships, in the way that linguistic data have been examined in this paper, we find that they too give rise to a network of relationships, and concepts turn out to be representable as positions whose properties are entirely given by what they are connected to in that network. Thus the points at the top of the linguistic network are positions in another network, and the linguistic network and cognitive network are two parts of one large relational

network. Now that the elementary relationships and diagramming notation are familiar it will not be necessary to go through such a painstaking account as that given above for the linguistic system, and we can move directly to some examples of the representation of non-linguistic information.

In the game of baseball, there are three quite different types of phenomena which serve the same function, that of the strike -- or at least they are almost the same in function: the swing-and-miss and the called strike can serve as any of the three strikes allowed a batter, but a foul ball can only function as the first or second strike; otherwise it has zero function. Three strikes make an out, but this is only one type of out; my cognitive system contains three others, as shown in the diagram. Upon receiving three outs the side at bat is retired. There are two sides, known as the visitors and the home team, of which the visitors are up first. When the visitors and the home-team have both been retired the first time, the first inning is over, and there are then eight additional innings like the first, after which the game is complete. All of these facts, which form a part of my cognitive system, are represented in Figure 22.

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Insert Figure 22 about here

---

My knowledge of animal taxonomy provides another illustration. Figure 23 shows part of the taxonomy I happen to have acquired and retained in memory. Notice that the position mammals, for example, connects downward to types of mammals (extension) and upwards to properties of mammals (intension). The fact that cats, for example, have fur is

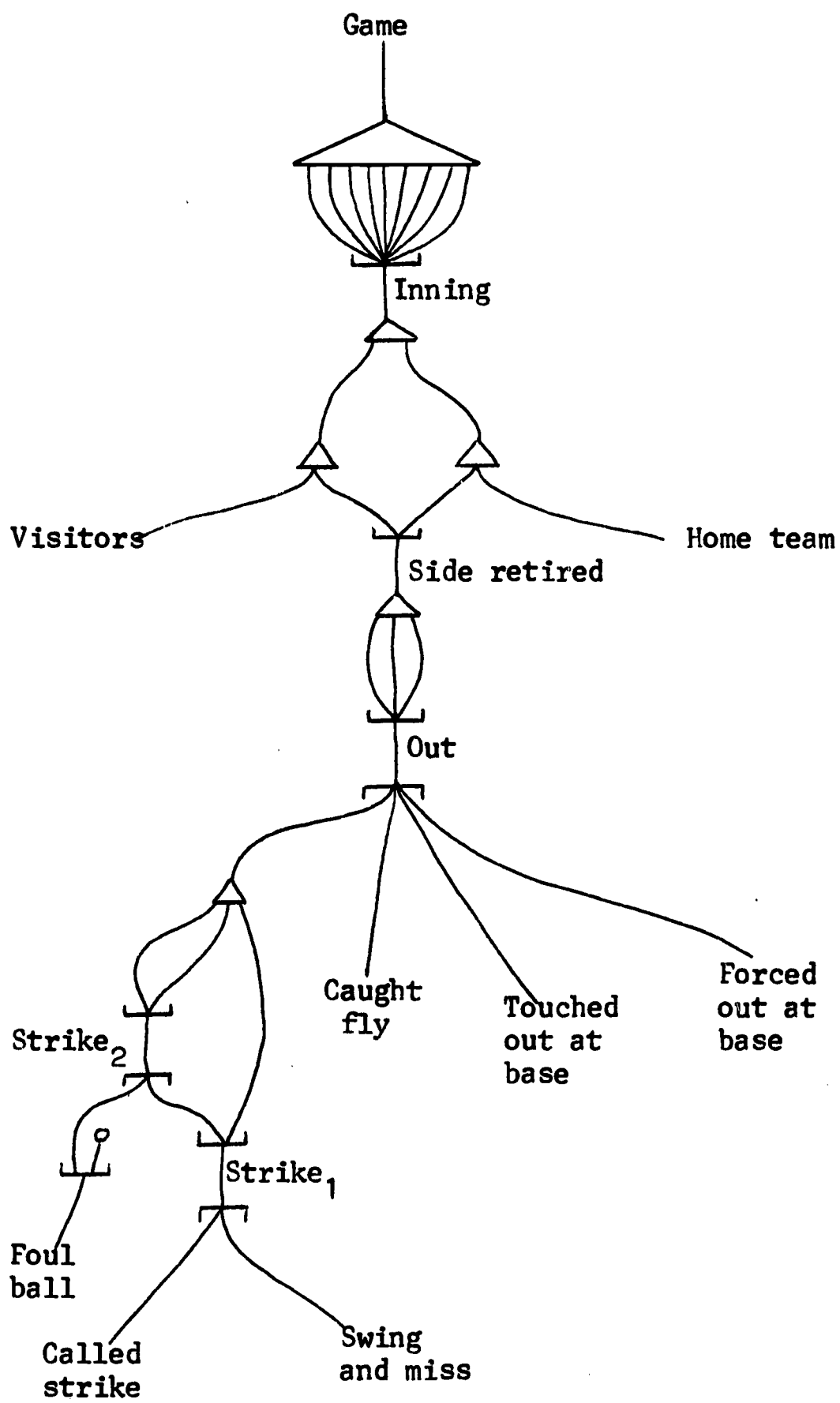
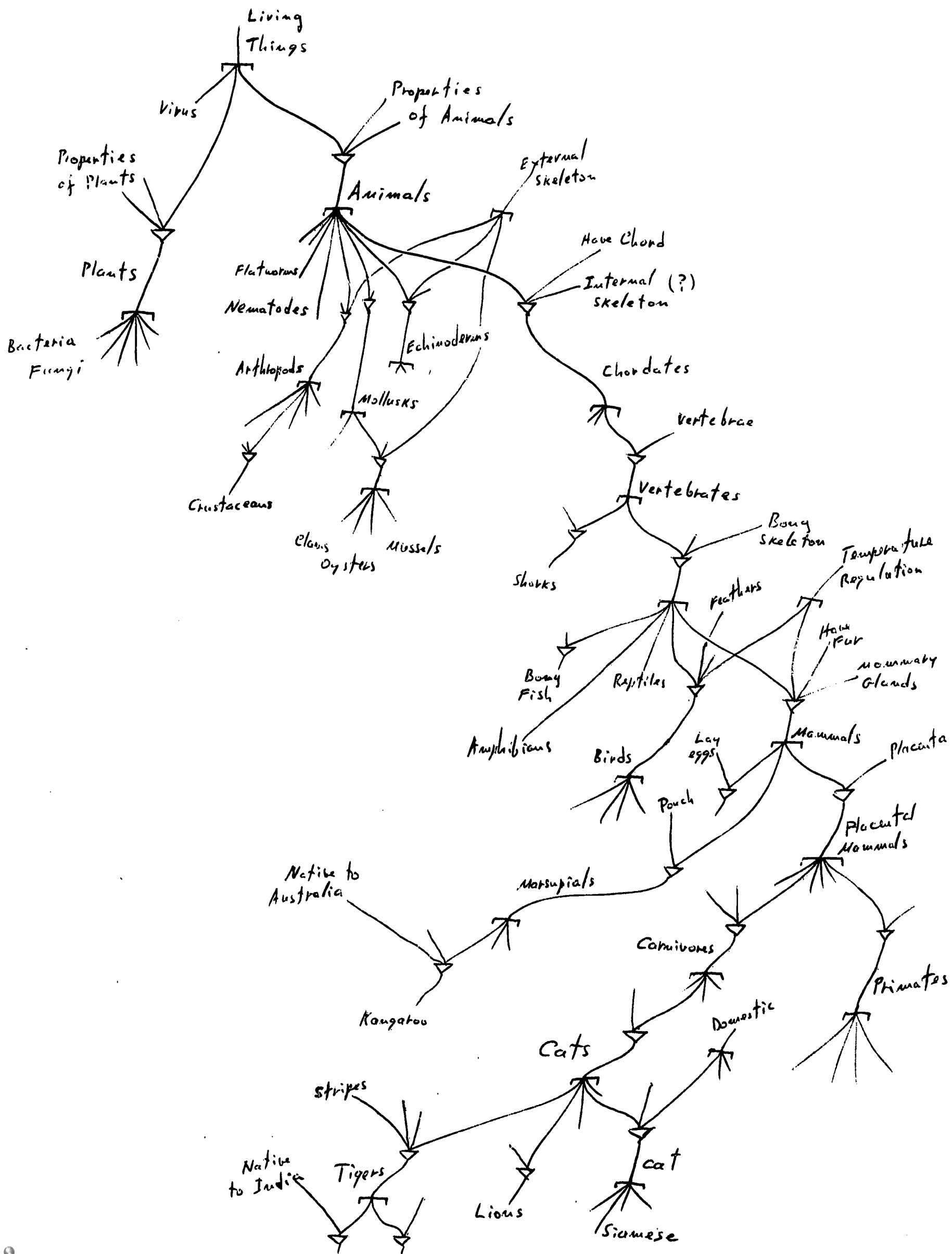


Figure 22



Figure 23

-25b-



represented by virtue of the fact that from the line Cats there is a path upwards to the property Fur, which is given just once for mammals in general. Other features of the diagram I leave to the reader's unguided examination. Here, the upward and downward directions do not have the same significance as in the linguistic network. Upward is toward fewer more general concepts, while downward is toward a larger number of more specific concepts. Not shown in the diagram are connections which some (but by no means all) of the lines have to the linguistic network.

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Insert Figure 23 here

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Many further examples are possible, but let us consider just one more: the network representation of "All men are mortal; Socrates is a man; therefore Socrates is mortal." The first premise, upon decoding, provides the property of mortality to everything in the set of men, as indicated in Figure 24a. The second premise puts Socrates into that set, as shown in Figure 24b.

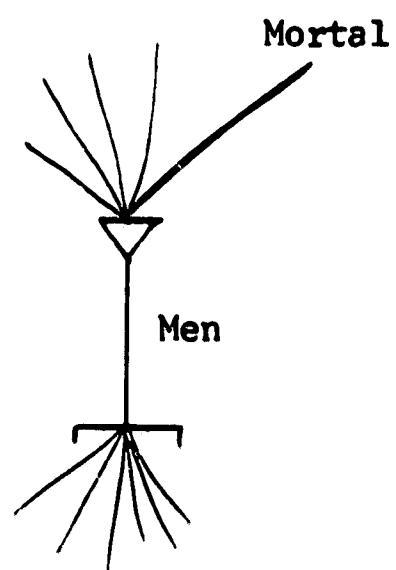
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Insert Figure 24 about here

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We may now, by the universal rules of following paths in relational networks, connect Socrates with mortality as one of his properties, which means that the conclusion of the syllogism is shown as implicit in the knowledge presented by the two premises.

(a)



(b)

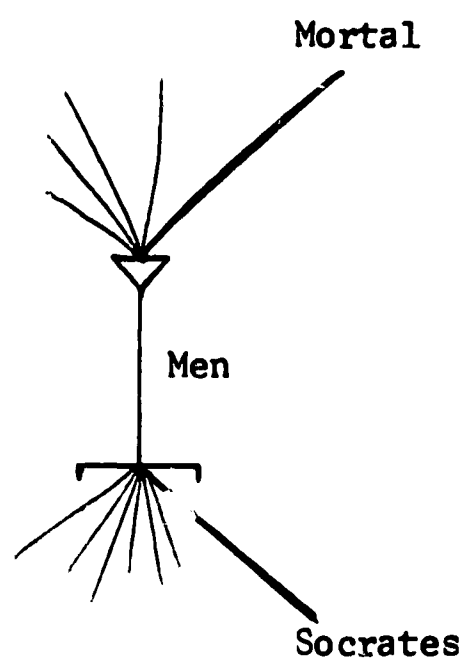


Figure 24

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Note

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